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Evaluation of elite cowpea lines for dual purpose (leaf/fodder plus grain)*

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Cowpea, which fits well into the cropping systems of several parts of Africa, is also a nutritionally important crop. Its grains, eaten by humans, have considerable protein; its tender leaves are cooked as a vegetable with cereal diets; and its haulms are used as livestock feed. Past research has focused on assessing and improving cowpea for these multiple traits. This article, based on genetic analysis, points to the need for a more specific strategy of dual targets, such as leaf plus grain or grain plus fodder, to suit regional consumption needs.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important grain legume of the lowland humid tropics and the semi-arid areas (Rachie and Roberts 1974). In Africa, it is widely distributed in cultivated and wild forms (Ng and Marechal 1984). In the West African savannas and the Sahel, cowpea is grown because it yields both grain for human consumption and haulms for animals (Foster and Mundy 1961). In eastern Africa, the tender leaves are periodically plucked and cooked as a side dish to the staple maize meal (Imbamba 1973). Thus, not only the grain but cowpea vegetative parts also make an important nutritional contribution (Lush 1978).

Cowpea morphology exhibits large variation, including both determinate and indeterminate types (Fery 1984). These range from climbing and spreading to dwarf and/or erect forms. Significant progress has been made in breeding determinate erect varieties with high grain yield and early maturity (Rachie 1984). Such types do not produce many leaves over an extended period. A concern has been raised that with such a thrust, the tendency may be toward the creation of cowpea types unsuitable for dual-purpose utilization, because cowpea types developed solely for grain may not provide the needed high fodder or vegetable leaf yields and ground cover.

A systematic effort was initiated at the International Institute of Tropical Agriculture (IITA) to identify potential dual-purpose varieties, and parents for use in a hybridization program devoted to the development of dual-purpose germplasm.

Materials and Methods

Experiments were conducted at IITA, Ibadan, Nigeria, in 1985 and 1986. Ibadan is located at 7°30' N and 3°54' E. The site lies in the tropical rainforest zone and it is characterized by bimodal rainfall, with a monthly mean of about 160 mm in the first growing season (April–June), and 150 mm in the second (September–October). The experiments were conducted on a tropical Alfisol: 32 advanced breeding lines, pedigree selected over seven generations, were evaluated during the first season of 1985; 24 lines from these were selected and evaluated in the second season in the same year. The most promising 16 lines were again selected from the 24 and evaluated in the first season of 1986 (weather data for these seasons are given in Table 1).

The study was planted in a split-plot design, replicated three times. A plot consisted of four rows, each with 20 hills hand-planted 20 cm apart within the row and 60 cm between rows. Three seeds per hill were later thinned to two 15 days after planting. Three sprays of deltamethrin (as Decis®) were applied at 25 cc a.i. ha^{-1}, the first just before flowering and subsequently at 10-day intervals, for full protection. Plots were hand-weeded to control weeds. Leaves were picked following the practice normally adopted by farmers in East Africa. The third and fourth leaves from the apical bud from all the plants in the two middle rows were picked. With branches, however, the entire apical buds, including the third and fourth leaves, were picked. Leaves were picked at weekly intervals starting at 28 days after planting (DAP). Leaf picking comprised the main plots,

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Table 1. Weather data for the 1985 and 1986 growing seasons at IITA, Ibadan.

Season/Month	Year	Rainfall (mm)	Relative humidity (%)	Temperature (°C) Min.	Max.	Mean
First season						
Apr	1985	142.1	73.0	23.6	32.2	27.5
	1986	70.8	74.8	20.9	31.9	26.4
May	1985	163.0	79.0	23.0	30.6	26.9
	1986	135.8	78.3	20.9	31.9	26.4
Jun	1985	230.0	80.0	22.6	29.1	25.9
	1986	136.0	79.0	28.6	30.2	29.4
Second season (1985 only)						
Sep		302.6	81.0	21.4	27.8	24.7
Oct		162.4	77.0	22.1	29.9	26.0
Nov		37.1	73.0	23.2	31.2	27.3

with varieties as subplots. Yield components, including number of pods plant^{-1}, seeds pod^{-1}, and 100-seed weight were recorded on five plants randomly taken from each plot. At the last seed harvest, all plants in the central two rows were cut at soil level and both fresh and dry forage yields determined. Data were analyzed using standard ANOVA techniques (Steel and Torrie 1980).

Results

Fresh leaf yield

Significant differences ($P = 0.05$) in fresh leaf yields were detected among the 16 entries. Total fresh leaf (TFL) yields ranged from 1.7–6.0 t ha^{-1}. An IITA medium-to-late maturity entry, VITA-3, developed in the 1970s ('old line') was the highest yielding. Two others, next in yield—an old line Tvx 1948-01F and a new (1983 selected) aphid-resistant entry—gave the next highest yields, but they fluctuated seasonally in the order of 50% between their highest and lowest TFL weights (Table 2). The remaining entries, mostly photoperiod-insensitive and early-to-medium in maturity (i.e., < 35 days to flower) gave low TFL and only 2-3 pickings before flowering.

Days to flower were positively correlated with days to maturity ($r = 0.66$, $P = 0.05$), which in turn correlated with TFL ($r = 0.42$). However, TFL yields were significantly ($P = 0.05$) but negatively correlated with total pods ($r = -0.29$), total grain ($r = -0.38$) and 100-seed weight ($r = -0.48$). Generally, lower TFL yields were associated with entries flowering within 40 days. Yields were high with late-flowering genotypes, but they fluctuated widely with season (Table 3).

Generally, TFL yield was highest in the 1985 first season, and less in 1986. Also in 1985, most lines were delayed in flowering by about 5 days compared with the subsequent seasons. Leaf-picking (before flowering) had no significant effect on the number of days taken to flower.

Grain and fodder yield

Leaf-picking (before flowering) had no significant effect on grain and fodder yield. Total grain yield was significantly but negatively correlated with the maturity of entries, whether or not their leaves had been picked. Grain yield was, however, significantly and positively correlated with total pod weight ($r = 0.81$, $P = 0.05$). Entries differed significantly in number of pods plant^{-1}, seeds pod^{-1}, and 100-seed weight.

A median value was used to divide entries into four groups: (a) high grain + high leaf/fodder, (b) high grain + low leaf/fodder, (c) low grain + high leaf/fodder, and (d) low grain + low leaf/fodder (Figs. 1 and 2).

Discussion

Late flowering and/or indeterminate growth appeared to be traits characteristic of the three best leaf-producing genotypes. Although flowering and indeterminacy are

Table 2. Total cowpea leaf yield (t ha^{-1}) of the best yielding lines of the 16 selections.

Entry	Total fresh leaf yield 1985 1st season	1985 2nd season	1986 1st season
VITA-3	9.3	4.9	3.9
IT83S-755-1	8.2	2.3	4.7
Tvx 1948-01	7.7	4.2	2.9
SE±	.73	.37	.22
LSD ($P = 0.05$)	1.2	.63	.36
CV(%)	26.6	25.1	16.5

Table 3. Comparisons in selected lines for initiation of flowering in relation to total yields (t ha^{-1}) of leaf (TFL), grain, and fodder on leaf-picked plants.

Lines	1985, 1st season TFL	Grain	Dry wt fodder	1985, 2nd season TFL	Grain	Dry wt fodder	1986, 1st season TFL	Grain	Dry wt fodder
Early (30-35 DFF[1])									
IT81D-789	2.9	1.8	1.3	-	-	-	2.0	1.1	1.0
IT82E-18	4.4	1.5	1.2	3.7	0.5	1.6	2.9	1.3	1.3
Medium (35-40 DFF)									
IT83S-672-10	4.1	1.1	1.7	2.6	0.5	5.3	2.1	1.4	1.7
IT83S-841	4.2	1.0	2.0	3.0	0.5	2.6	2.0	1.2	1.3
Late (> 40 DFF)									
Tvx 1948-01F	7.7	1.5	2.0	4.2	1.1	4.3	3.0	1.1	1.5
VITA-3	9.3	0.05	1.4	4.9	0.6	7.2	4.0	0.6	2.3
IT83S-755-1	8.2	0.07	1.4	2.3	0.5	4.5	4.7	0.7	2.3

1. Days to first flower.

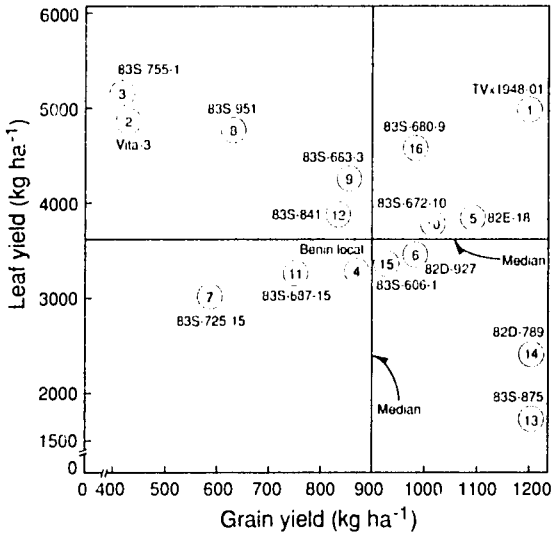

Figure 1. Grain versus leaf yields of 16 dual-purpose cowpea varieties.

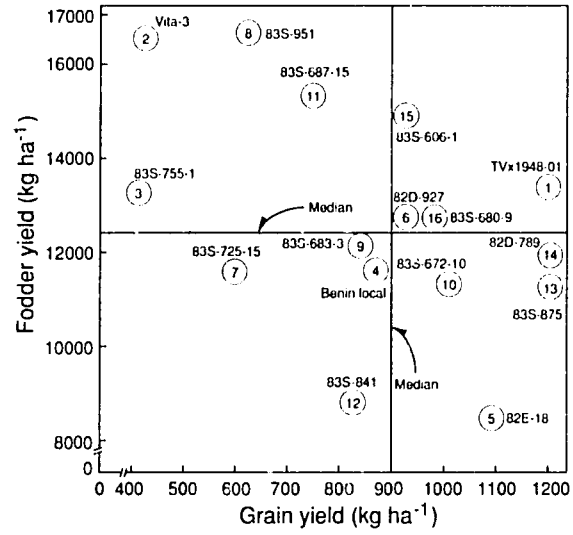

Figure 2. Grain versus fresh fodder yields of 16 dual-purpose cowpea varieties.

moderately to highly heritable, they are under separate genetic control (Fery 1984). The apparent moisture effect in the delay of flowering during the first season of 1985 appears to have been environmental in nature, and not necessarily from photoperiodic sensitivity. In VITA-3, Tvx 1948-01F, and IT83S-755-1, which have indeterminate growth habit, TFL yields appeared highly responsive to prolonged precipitation in the 1985 first season. In that year, these varieties formed dense stands and remained lush until late flowering (during the long rains) of the first but not the second season. It is known that many crops mature faster when water is reduced toward the end of a growing season (Major 1980). Therefore, the most obvious sustained vegetative growth under the abundant moisture supply in 1985 was a response to environment, possibly attributable to some large genotype x environment interaction. In improvement efforts, the latter could limit progress in selection for dual-purpose traits.

Upper yield limits could be set arbitrarily at > 5 t ha^{-1} for fresh leaf and ≥ 12 t ha^{-1} for fodder. Only one or two entries attained these limits (Figs. 1 and 2). However, a multitrait such as high grain plus fodder yield is likely to be difficult to incorporate into a single genotype of a short-to-medium growing season. From Figures 1 and 2 it can be observed that Tvx 1948-01F was in the high grain plus high leaf ranking category, but not strictly the highest fodder producer as well. It had, on the other hand, the best combination of both high grain and high leaf/fodder. When planning a breeding program, it might be easy to assume that good leaf-producing genotypes would also produce an acceptable amount of fodder. This may not necessarily be so, but the relationship between the two attributes is definitely not negative. There is a likelihood also that in superior leaf-yielding genotypes, high grain yield might be negatively correlated with high leaf yield. Since late-maturing types are likely to be good leaf yielders, to expect any positive association with grain yield means that a given genotype must be able sufficiently to partition its photosynthate to both the sink (the grain) and the source (i.e., the vegetative component) in equal measure.

Such a genotype is possible, particularly if the two traits are under manipulable genetic control(s) or the traits are not adversely correlated. Some traditional dual-purpose cowpeas are known to yield adequate grain as well as leaf (Akundabweni, unpublished data), when fully protected from insect pests. It could be assumed, therefore, that high grain yields and abundant foliage are not incompatible merits in a single genotype. In some past yield trials involving VITA-3, Tvx 1948-01F, and IT83S-755-1, for instance, grain yields have appeared promising.

The negative correlations between grain yield and leaf production observed in this study could have been due partly to the decumbent habit of some of the indeterminate top leaf-yielding entries. They might have been unable to carry all their pods above the leaves because of their poor skeletal (woody) tissue. Consequently, most pods, when produced underneath the canopy, might have succumbed to disease damage. *Choanephora cucurbitrum* (Singh and Allen 1979) adversely affected the pods of IT83S-755-1 and VITA-3 during the first season in 1985 when seed yields were observed to be low.

High grain plus high leaf/fodder yield potential is a complex trait, and progress can be expected only if the heritable components of the multitrait are well understood. This requires a quantitative study of the magnitude of the genotype x environment interaction and how it could be minimized in genotype assessment and selection for dual-purpose types. Following this, an attempt could be made to transfer factors responsible for high yield expression from the high grain but low leaf/fodder genotypes (e.g., IT83S-875) into the high leaf/fodder but low grain producers (e.g., IT83S-951) by crossing (see Figs. 1 and 2). Finally, a suitable dual-purpose and multitrait selection index might be necessary for effective culling of poor combinations and segregations in early generation crosses.

The results of this study have revealed potential grain, leaf, and fodder yields and their interaction in a range of cowpea varieties. This information can be used in guiding an ongoing breeding program to develop dual-purpose varieties. In view of the fact that dual purpose varieties in East Africa are primarily for 'leaf and grain' whereas dual-purpose varieties in West

Africa are primarily for 'grain and fodder', the current breeding strategy is to develop two sets of dual-purpose varieties to suit these regional preferences. This will also eliminate the need for simultaneous selection for leaf + grain + fodder yield, which is less efficient than selection for leaf + grain or grain + fodder.

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